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ORCHID CONSERVATION BEYOND THE NINETEENTH CENTURY

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ABSTRACT. Orchid conservation is currently limited by a century old paradigm, rooted in the herbarium centered inventories of imperial resources, the Europe of Great Powers and steamships, and orchids as playthings of a small upper class. Genetics, ecology, population biology were in the future, and horticultural techniques for growing and for large scale propagation were unsatisfactory. A major revolution in nearly every aspect of orchid science, growing, and relations to society, spread over the past 100 years but accelerating in the last 25 years, calls for new systems approaches to the urgent need for action on orchid conservation. Many present attempts are inappropriate, based upon outdated ideas. Others are so slow and cumbersome that little or no actual conservation can be carried out. These same policies inhibit many types of research on orchids. An improved system would save species from extinction and open possibilities for significant new insights in evolutionary biology. The first step is offered here: downlisting many orchids from CITES II.

In 1818, Lord Byron wrote, in Don Juan, Canto the First, ciii:

> 'Twas on a summer's day—the sixth of June:— I like to be particular in date, Not only of the age, and year, but moon; They are a sort of post-house, where the Fates Change horses, making history change its tune, Then spur away o'er empires and o'er states, Leaving at last not much besides chronology, Excepting the post-obits of theology.

At the beginning of the 19th Century orchid botany and horticulture were at a very low state. Orchids had been known for millennia, but Linnaeus, back in 1753, had described only 62 species for the world (Stearn 1975). Greenhouses, growing media, etc. were utterly dismal and very nearly useless. Botany consisted of little more than vague taxonomic descriptions, based upon dried scraps from even more vague origins. Dogmatic assertions, such as that tropical orchids were parasites, that they grew in the very hot, steamy, windless dark places of forests adjacent to colonial ports, and so forth, dominated growing. A series of European empires had been looting the world of whatever they deemed valuable, classical art to timber, furs, spices, gold, slaves, etc. There was little interest in developing new sources of wealth, since resources for the taking, usually with force, were abundant. The Congress of Vienna had imposed at bayonet point a new system of European powers. Private associations of any sort by ordinary people were illegal or regarded with great suspicion. Books were few and poorly illustrated; periodicals, even fewer. Scientific facts were few and far between, treated as a result in isolation. They were mixed with a great deal of non-facts. All explanations were ultimately theological. "For what purpose did God adorn the Earth with these orchideous plants?" Lindley (1833) could ask in a scientific paper. The world was not quite 6,000 years old, might end at any moment. conservation was of no concern. Two men did have the foresight to consider it. "Where flowers degenerate, men cannot live," said Napoleon. The German court official Goethe put a remarkable prophecy of environmental and human destruction by a giant agribusiness near the end of Faustus (Raphael 1965).

That was the world Byron wrote in and would soon die in. It was limited by what could be done and seen by many as unchanging. Lord Amherst, Viceroy of India, would govern by the motto: "Do nothing and allow nothing to be done." Yet steamships, railroads, telegraphs were about to transform communications and travel. Byron's own daughter, Augusta Ada, Countess of Lovelace, would become the first computer programmer.

President John F. Kennedy once said, "Things do not happen—they are made to happen." In the three-quarters century that followed Byron, many things were made to happen. By the end of the century, Europe and North America had been transformed. Industries created plentiful supplies of cloth, ceramics, iron and steel, chemicals, etc. Most people still lived on farms, and had little education, but this was about to change. A few empires had taken over much of the world, and were considering hostile takeovers of each other. Borders were guarded by customs bureaucracies and by fortifications. Overseas trade was essentially natural resources shipped back to Europe and to the northeastern U.S.A. Naval blockades were thus a major strategic concept. Each empire wanted to contain all of the resources used by its home economy

(Sprout 1941). But the growing populations, especially in major cities, led to erosion and deforestation of farming regions, threatening the food supplies. Agricultural colleges, experiment stations, governmental agencies for agriculture and entomology arose to deal with these problems. Botany was expanding into new fields and a great popular interest in natural history led to many books and periodicals. The empires tried to inventory their resources, resulting in a great influx of specimens. Botanists had to become narrow specialists to deal with this. In general, they treated orchids as a rather useless, but large subject. Horticulturally, there were state-run botanical gardens near capital cities that displayed orchid oddities as part of the imperial grandeur. The plants were a frill, a hobby of conspicuous consumption by a few of the wealthy. In some ways, orchid growing was comparable to the newly invented motor car—a toy for a few, that clearly would never have any widespread use or interest.

Growing techniques were greatly improved, and artificial hybrids were even being regularly produced upon a small scale. Yet the records of the late 19th Century imply, or in a few cases openly admit, that most orchids were short-lived in the greenhouses. They were collected by the thousands in the wild, shipped back with high mortality rates, then placed in stuffy greenhouses, with little disease control, little if any fertilizer, and poor light under polluted northern skies. Most dwindled away, but now and then a few plants thrived, to universal astonishment.

Heinrich G. Reichenbach sealed his herbarium for 25 years (1889–1914) in reaction to the situation. Robert Allen Rolfe of Kew, became very concerned about conservation. Unfortunately, the prevailing paradigm was to preach at people, and when they did not repent, walk away smugly satisfied that the failure was in their moral character. Perhaps something would be muttered about needing a law. To people used to seeing orchids as single plants or small groups, collecting 10,000 of a species seemed outrageous. No one even asked about, much less did, field work to determine the size and extent of wild populations. In any case, nearly all of the species believed to be exterminated by the Victorian collectors turned up in quantity during the 20th Century.

Let us imagine a possible, but not actual, scene that could have happened 100 years ago, today. Into the office of R. A. Rolfe come two young men. By coincidence they have just landed in England on separate ships. One is an American, due to start his senior year at Harvard in the autumn, Oakes Ames. The other is a German graduate student, Rudolf Schlechter, who has been exploring Africa for orchids. He is setting for himself the goal of describing one new species per day. Suppose that these three men engage in conversation upon the current and future state of orchids. Mycorrhiza and chromosomes have just been discovered. Viruses are unimagined. Mendel's work will not be noticed for another three years. That will mean 35 years were lost to biology and to society.

The three orchid lovers might have predicted enormous sets of encyclopedic books, giving all that was known. Perhaps photography would play a greater role, and if labor costs go down, some published photos could be hand-tinted. Few new species could be expected in the major garden genera, but thousands of small-flowered orchids, that would never be of interest to growers, awaited discovery. They would probably have guessed that hundreds, even several thousand hybrids would be made in the next century. But they would not seriously imagine any great amount of orchid growing in the tropics and subtropics. After all, diseases and the unbearable heat would forever bar people of the advanced nations from living well over prolonged periods of time, in places such as Florida or Singapore. And it was openly expressed or simply taken for granted that advanced intellectual, economic, and military achievements were only possible in cool, strongly seasonable climates, carried out by the only nations capable of intelligent and industrious efforts. We smile or we are outraged upon being reminded of such attitudes of not so long ago. Prediction is notoriously narrow, inaccurate, and biased. And it rarely makes things happen.

The most complex, cruel, fast changing, surprising, hopeful, terrifying, disastrous, successful, accomplished, extraordinary century in all of human history came. A great revolution took place in orchid growing. There are now more than 100,000 hybrids, and millions of plants travel by air. Hundreds of new species are discovered each year, including many wonderful new members of the major horticultural genera. There are hundreds of orchid clubs and thousands of books and periodicals. There are botanical gardens in most U.S. cities, judging and shows, and nurseries with technically sophisticated growers. All of this arose in a new kind of world society and economy, with most of the changes during the last 30 years or so. There is now a dominant urbanized educated middle class consumer society, a recognition of diversity as strength, the shift of wealth, power, and the cutting edges of civilization towards the Sunbelt and the Pacific Rim. Now we have computers and electronic communications, air travel, continent-wide free trade areas, a global finan-

cial economy (20–50 times the production economy [Schwartau 1994]). The empires mostly vanished, the nations increased in numbers while beginning to lose their relevance in many areas (Toffler & Toffler 1993). What is now called an Information Society appeared, and people increasingly turned to others who shared their interests, regardless of family, nationality, religion, etc.

Not everyone got the word. Many decision-makers exhibited what social scientists call cultural lag (Ogburn 1950, Hall 1976). They tried to hang on to the 19th Century methods of centralization of authority, red tape, borders, bureaucracy, preaching duties and morals—methods that all too often do nothing and allow nothing to be done. Those who wanted to make things happen, particularly those who wanted to respond in diverse and flexible ways to rapid changes, became alienated in ways Marx never imagined. And there were a number of academic do-nothings, wanting to ceaselessly study and criticize, but never act. When the governments did act, it was all too often destructive: military adventures, massive development schemes, destructive overexploitation of resources, encouraging overpopulation, etc. (Thomas 1956, Spencer 1969, Hardin 1972, Hardin & Baden 1977, Benjamin & Freedman 1989, Roberts 1993, Dailey 1995, Gibbs 1995, Fischer 1996, Costaza *et al.*1997, Pimm 1997, Ridley 1997). As a result, much of the Earth's surface is now ruined to varying degrees. Some places like Florida have virtually no genuinely natural habitats left. If we are ever going to save anything of nature in such places, we have to act now rather than continuing to delay. Positive feedback in national economies have led to instabilities, such as the very high interest rates in Third World countries that force rapid short-term exploitation, rather than sustainable long-term efforts (Hecht 1992, Holmes 1993, Fischer 1996, and McRae 1997, Rice *et al.* 1997).

It is a great mistake to imagine that people of a century or more ago were just like us, except that they lacked the benefits we enjoy: TV, air wars, A Bombs, political correctness, unlimited vulgar self expression and feel-goodism, inflation, etc. There are differences in motives, such as people now wanting freedom and autonomy instead of belonging and following other people's rules. Above all, we are in an Information and High Tech Society, based upon progress in science. Knowledge has increased exponentially during this century. This is not just adding bricks to a pile, rather it leads to major restructuring of thought. Cultural lag prevents many from grasping this. For centuries, there were few tourists. Examples included Herodotus in the 5th Century BC (Selincourt 1954), J. F. Genreli Caneris in the 17th Century (MacLiesh & Krieger 1962), and Byron and his friends. Large scale tourism began in the last half of the 19th Century, when trains and steamships were widely operating. Now it is one of the largest industries everywhere. The scale of tourism destroys the 19th century style of control of international transporting of plants. Last winter, about 350,000 people passed through air terminals in the U.S.A., in one day. Facilities and officials are increasingly overwhelmed. Control of pests, diseases, weeds, drugs, horticultural imports, whiskey, etc. seems to be more and more of a lost battle. Orchid people tell one another hilarious stories of their airport adventures.

In another area, Latin America and eastern Asia have changed from exploited sources of raw materials, populated by a few rich and millions of illiterate peasants. About 25% of the world's construction cranes are now working 24 hour days in and around Shanghai (Will 1997). Thriving cities, prospering from world trade, consume resources, including orchid plants, at an increasing rate. One commercial grower, in a large South American capital, recently told a friend of mine that he has a local market of about 100,000 orchid buyers. So the old sailing ship concept of international checkpoints is hopeless as a conservation strategy.

We do not just add bricks to a pile, because the amount of knowledge is now so great. Formally distinct specialties have now merged. I have many difficulties in filing scientific papers on conservation, because most papers no longer fit inside one pigeon hole. Population biology, ecology, evolutionary genetics, biogeography, and other subjects interact, even in short papers (Brockman 1995). We have to look at systems, not just isolated facts. Systems are often counterintuitive. (Olson 1971, 1982, Stern 1993). They can sometimes be powerfully influenced by identifying sensitive trigger points and making things happen to them. Sometimes. For each fact or relationship (and it is the relationships that usually matter), we must ask: how do we know about it, how accurate is our knowledge, what crucial information do we need to find out (organizing our ignorance), can we make some order of magnitude calculations (Fermi questions; Von Baeyer 1993) and then test these by acting? (Platt 1966, Miller 1978, Eigen & Winkler 1981, Prigogine 1984, Lewin 1992, Kauffman 1993, Levy 1993, Cohen & Stewart 1994, Gell-Mann 1994, Kelly 1994, Coveney & Highfield 1995, Czilko 1995, Kauffman 1995, Stewart 1995, and Bailey 1996).

New maths have appeared. Simulations and modeling, which are not Newtonian calculations

nor predictions, clarify ideas. The old ways were top-down, in society and in science (Olson 1971, 1982). They sought single precise answers, central tendencies with everyzthing else treated as errors. The new ways are bottom-up, involving widely distributed, complex populations, diverging but subject to selection. Ever changing, opportunistic, such ways lead to maximum flexibility and creativity (Eigen & Winkler 1981, Perry 1995). Evolution works this way (Kelly 1994, Cziko 1995, Dennett 1995). Science works this way (Bailey 1996). Evolution makes things happen. Science makes things happen. These things cannot all be good from our point of view, and they often carry unwelcome costs and side-effects. But they happen, unlike the costly unproductive alternatives.

In orchids we need to learn about natural populations (Hagsater & Dumont 1996). How many individuals? What happens to them? If the species forms meta-populations, with constant changes in the individuals and their sites, there will be obvious problems in tracking these (Horn 1972, Grubb 1977, Hanski 1983, 1994, Wade & McCauley 1988, Cohen 1991 & Levin, McCauley 1992, 1994, Goldwasser *et al.*1994, Molofsky 1994, Tilman *et al.*1994). The conservation problems that result will not be easy to solve. Rapid Assessment Programs (RAP) have been used to study tropical trees. We must find ways to extend them into three dimensions. Coral reef studies may have things to teach us about this (Hastings 1980). Island biogeography transformed our thinking, but it does not work well with trees or orchids (Thornton 1996). They are long-lived and may expand their numbers after disturbances and clearing. The discovery that *Streptomyces* destroys mycorrhiza (Perry 1995) raises new questions. So do endophytic fungi inside orchid stems and leaves (Petrini & Dreyfuss 1981, Lamboy 1984, Atsatt 1988, Carroll 1988, Clay 1988, Gehring & Whitman 1994, Roy 1994, Travis 1996), and the ability of some terrestrials to become leafless and subterranean for years.

Darwin saw orchids as major tools to test central biological theories. We know of such problems as deception pollination flowers, highly variable rare endemic species, widespread and variable self pollinating or apomictic orchids, that challenge the present concepts of evolutionary biology. We need to bring orchids back into the mainstream of biology. The literature on conservation biology is rapidly growing, yet, orchid people seem disinterested or unaware of its existence. We need to bring biology, especially those parts that are tied to conservation, back into orchids. All of this involves studies of living plants in nature, in greenhouses, in labs, in flasks. We also need to tie orchid conservation into society. We have come a very long way in 100 years. We need to look at motives and marketing in regard to orchid conservation: parks, preserves, rescue, restoration, ecotours, and photography, display, education, and autodidactic learning, fantasies, collecting motives, medicine and pharmacology, landscape design, consumption, sustainability—yet how much do we really know about these matters (Berelson 1964, Shepard 1967, 1973, 1982, Spencer 1969, Hall 1976, Odell 1980, Rolston 1986, Norton 1989, Orr 1992, Gibbs 1995, Kellert 1996, Ospina 1996)? Orchids can be flagships to rally public support for protecting nature. They are even moving into outer space (Czerevczenko & Kosakovskaya 1990). A better understanding of island biogeography (which they might give us) may become critical out there in the next century or two (Barrow & Tippler 1986, Terra 1991).

We can only do these things in a modern multiple distributed effort, free to explore and learn, subject to corrective selection (Kelly 1994, Dennett 1995, Bailey 1996). Mistakes will be made. This is how science has long operated, and the new concepts in math and other fields demonstrate that we must learn to work this way. Mistakes will be made, should be made, if there is to be progress, but results will be achieved. That is why we are proposing that most orchids be downlisted from CITES (TABLE 1), to free all orchid people for conservation, scientific, and recreational efforts. More than 95% of the world's orchids have never been in the slightest danger from over-collecting, and no legitimate basis for regulating international movement in them was ever offered. We lost 35 years with many tragic results because Mendel's work was in limbo. We have lost a half century or more because the world leaders will not face and deal with overpopulation and its results. We have lost 20 years because orchid conservation and research was snarled in counterproductive red tape. Instead of doing nothing and allowing nothing to be done, while the forests are cut and burned and the loss of species take place, let us have some fun and let us make some constructive things happen.

> It was upon a day, a summer's day;—Summer's indeed a very dangerous season, And so is spring about the end of May; The sun, no doubt, is the prevailing reason; But whatsoe'er the cause is one may say, And stand convicted of more truth than treason, That there are months which nature grows more merry in,—
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> "Things do not happen—they are made to happen."

TABLE 1. Proposed taxa of Orchidaceae for downlisting from CITES Appendices I & II. These taxa proposed for downlisting rarely or never appear in commercial offerings. The exceptions and possible exceptions mentioned include virtually all orchid species routinely grown on any scale as commercial items for international trade. These exceptions also include a large percentage of the species important in hybridizing. As quantities of seedlings of these exceptions become more numerous, there will be less need to keep them on CITES. Classification follows Dressler (1993).

Subf. APOSTASIOIDEAE
Subf. CYPRIPEDIOIDEAE
Exceptions: *Paphiopedilum, Phragmipedium* (including *Mexipedium*), and European species of *Cypripedium.*
Subf. ORCHIDOIDEAE
Exceptions: all tribe Orchideae from Europe, Mediterranean, and Middle East.
Possible exceptions: Tribe Diurideae from Australia and New Zealand; *Disa* spp. from South Africa.
Subf. SPIRANTHOIDEAE
Subf. EPIDENDROIDEAE
Arethuseae
Calypsoeae
Coelogyneae: Possible exception: *Pleione.*
Cymbideae: Exceptions: *Cymbidium, Eulophiella, Ansellia*
Dendrobieae: Possible exception: *Dendrobium* spp. of Section *Dendrobium.*
Epidendreae: Exceptions: *Cattleya* spp., *Laelia, Sophronitis, Quisqueya*
Gastrodieae
Malaxideae
Maxillarieae: Exceptions: *Lycaste, Anguloa, Psychopsis*
Neottieae
Nervileae
Palmorchideae
Pleurothallidinae: Exceptions: *Masdevallia, Dracula*
Podochileae
Triphoreae
Vandeae: Exceptions: *Phalaenopsis, Doritis, Kingidium, Nothodoritis, Paraphalaenopsis, Vanda* (including *Euanthe*), and *Renanthera imschootiana, Aerides, Ascocentrum*
Vanilleae

LITERATURE CITED

ANDERSON N.G. 1970. Evolutionary significance of virus infection. Nature 227: 1346–1347.

ATSATT P.R. 1988. Are vascular plants "inside-out" lichens? Ecology 69: 17–23.

BAILEY J. 1996. After thought. The computer challenge to human intelligence. Basic Books, New York. 277 pp.

BARROW J.D. AND F. TIPLER. 1986. The anthropic cosmological principle. Oxford University Press, New York. 706 pp.

BENJAMIN M. AND A. FREEDMAN. 1989. Bridging the global gap. a handbook to linking citizens of the first and third worlds. Seven Locks Press, Cabin John, Maryland.

BERELSON B. AND G.A. STEINER. 1964. Human behavior. an inventory of scientific findings. Harcourt, Brace, & World Inc. New York. 712 pp.

BROCKMAN J. 1995. The third culture. Beyond the scientific revolution. Simon & Schuster, New York. 413 pp.

BYRON LORD G.G. 1943. Don Juan. a satiric epic of modern life. Heritage Press. New York.

CARROLL G. 1988. Fungal endophytes in stems and leaves: from latent pathogen to mutualistic symbiont. Ecology 69: 2–9.

CLAY K. 1988. Fungal endophytes of grasses: a defensive mutualism between plants and fungi. Ecology 69: 10–16.

COHEN D. AND S.A. LEVIN. 1991. Dispersal in patchy environments: the effects of temporal and spatial structure. Theoretical Population Biology 39: 63–99.

COHEN J. AND I. STEWART. 1994. The collapse of chaos. Discovering simplicity in a complex world. Viking, New York. 495 pp.

COSTAZA R., R.D. ARGE, R. DE GROOT, M. GRASSO, B. HANNON, K. LIMBURG, S. NAEEM, R.V. O'NEILL, J. PARUELO, R.G. RASKIN, P. SUTTON, M. VAN DEN BELT. 1997. The value of the world's ecosystem services and natural capital. Nature 387: 253–260.

COVENEY P.V. AND R. HIGHFIELD. 1995. Frontiers of complexity. The search for order in a chaotic world. Fawcett Columbine, New York. 462 pp.

CZEREVCZENKO T.M. AND I.V. KOSAKOVSKAYA. 1990. Tropical orchids in space research. Pp. 251–263 *in* J. ARDITTI, ed., Orchid Biology Volume V, Timber Press, Portland, Oregon.

CZIKO G. 1995. Without miracles. Universal selection theory and the second Darwinian revolution. MIT Press, Cambridge, Massachusetts. 385 pp.

DAILY G.C. 1995. Restoring value to the world's degraded lands. Science 269: 350–353.

DENNETT D.C. 1995. Darwin's dangerous idea: evolution and the meanings of life. Simon & Schuster. New York.

DRESSLER R.L. 1993. Phylogeny and classification of the orchid family. Dioscorides Press, Portland, Oregon. 314 pp.

EIGEN M. AND WINKLER. 1981. Laws of the game. How the principles of nature govern chance. Knopf, Random House, New York. 347 pp.

FISCHER D.H. 1996. The great wave. Price revolutions and the rhythm of history. Oxford University Press. New York. 536 pp.

FORMAN R.T.T. 1995. Land mosaics. The ecology of landscapes and regions. Cambridge University Press. UK. 632 pp.

GEHRING C.A. AND T.G. WHITHAM. 1994. Interactions between above-ground herbivores and the micorrhizal mutualists of plants. TREE 9: 251–255.

GELL-MANN M. 1994. The quark and the jaguar: adventures in the simple and the complex. W.H. Freeman & Co., New York. 392 pp.

GIBBS W.W. 1995. Profile: George F.R. Ellis, Thinking globally, acting universally. Scientific American. Oct. 1995. Pp. 50, 54–55.

GOLDWASSER L., J. COOK, AND E.D. SILVERMAN. 1994. The effects of variability on metapopulation dynamics and rates of invasion. Ecology 75: 40–47.
GRUBB P.J. 1977. The maintenance of species-richness in plant communities: the importance of the regeneration niche. Biological Revue 52: 107–145.
HAGSATER E. AND V. DUMONT, eds. Compiled by A.M. Pridgeon. 1996. IUCN/SSC Orchid Specialist Group. Status survey and conservation action plan: orchids. IUCN Publications Services Unit, Cambridge, UK. 153 pp.
HALL E.T. 1976. Beyond culture. Anchor Press/Doubleday. Garden City, New York. 256 pp.
HANSKI I. 1983. Coexistence of competitors in patchy environment. Ecology 64: 493–500.
——— 1994. Patch-occupancy dynamics in fragmented landscapes. TREE 9: 131–135.
HARDIN G. 1972. Exploring new ethics for survival.
HARDIN G. AND J. BADEN. 1977. Managing the Commons.
HASTINGS A. 1980. Disturbance, coexistence, history, and competition for space. Theoretical Population Biology 18: 363–373.
——— AND S. HARRISON. 1994. Metapopulation dynamics and genetics. Ann. Rev. Ecol. Syst. 25: 167–188.
HECHT S.B. 1993. The logic of livestock and deforestation in Amazonia. BioScience 43: 687–695.
HOLMES B. 1993. Few options for third world farmers. Science 260: 1894.
HORN H.S. AND R.H. MACARTHUR. 1972. Competition among fugitive species in a harlequin environment. Ecology 53: 749–753.
JEPPSSON L. 1988. A possible mechanism in convergent evolution. Paleobiology 12: 80–88.
KAUFFMAN S.A. 1993. The origins of order. Self-organization and selection in evolution. Oxford University Press, New York. 709 pp.
——— 1995. At home in the universe. The search for laws of self-organization and complexity. Oxford University Press, New York. 321 pp.
KELLERT S.R. 1996. The value of life. Biological diversity and human society. Island Press/Shearwater Books, Washington, D.C. 263 pp.
KELLY K. 1994. Out of control. The rise of neo-biological civilization. Addison-Wesley, Reading, Massachusetts. 521 pp.
LAMBOY W.F. 1984. Evolution of flowering plants by fungus-to-host horizontal gene transfer. Evolutionary Theory 7: 45–51.
LEVINS R. AND D. CULVER. 1971. Regional coexistence of species and competition between rare species. Proc. Nat. Acad. Sci. USA. 68: 1246–1248.
LEVY S. 1993. Artificial life. A report from the frontier where computers meet biology. The quest for a new creation. Vintage Books/Pantheon Books, New York. 390 pp.
LEWIN R. 1992. Complexity. Life at the edge of chaos. Macmillan Publishing Co., New York. 208 pp.
LINDLEY J. 1833. *Oncidium harrisonianum.* Edwards' Botanical Register 19: T 1569.
MACLIESH F. AND M.L. KRIEGER. 1962. The privateers. A raiding voyage to the great South Seas. Random House, New York. 366 pp.
MCCAULEY D.E. 1991. Genetic consequences of local population extinction and recolonization. TREE 6: 5–8.
——— 1994. Contrasting the distribution of chloroplast DNA and allozyme polymorphism among local populations of *Silene alba*: implications for studies of gene flow in plants. Proc. Nat. Acad. Sci. USA 91: 8127–8131.
MCRAE M. 1997. Is 'good wood' bad for forests? Science 275: 1868–1869.
MILLER J.G. 1978. Living systems. McGraw-Hill Book Co., New York. 1102 pp.
MOLOFSKY J. 1994. Population dynamics and pattern formation in theoretical populations. Ecology 75: 30–39.
NORTON B. 1989. Why preserve natural variety? 271 pp.
ODELL R. 1980. Environmental awakening. The new revolution to protect the earth. Ballinger Publishing, Cambridge, Massachusetts. 329 pp.
ODUM H.T. 1988. Self-organization, transformity, and information. Science 242: 1132–1139.
OGBURN W.F. 1950. Social Change. Viking Press, New York.
OLSON M. 1971. The logic of collective action. Public goods and the theory of groups. Harvard University Press, Cambridge, Massachusetts. 186 pp.
——— 1982. The rise and decline of nations. Economic growth, stagnation and social rigidities. Yale University Press, New Haven, Connecticut. 273 pp.
ORR D.W. 1992. Some thoughts on intelligence. Conservation Biology 6: 9–11.
OSPINA M. 1996. Orchids and ecology in Colombia. To the rescue of paradise. Mariano Ospina H, Vero Beach, Florida. 249 pp.
PERRY D.A. 1995. Self organizing systems across scales. TREE 10: 241–244.
PETRINI G. AND O. DREYFUSS. 1981. Endophytische pilze in epiphytischen Araceae, Bromeliaceae und Orchidaceae. Sydowia 34: 135–148.
PIMM S.L. 1997. The value of everything. Nature 387: 231–232.
PLATT J. 1966. The step to man. John Wiley & Sons, Inc., New York.
PRIGOGINE I. AND I. STENGERS. 1984. Order out of chaos. Man's new dialogue with nature. Bantam Books, Toronto. 349 pp.
RAPHAEL A. 1965. Goethe and the philosopher's stone. Symbolical patterns in 'The Parable' and the second part of 'Faust.' Garrett Publications, New York. 275 pp.
RICE R.E., R.E. GULLISON AND J.W. REED. 1997. Can sustainable management save tropical forests? Scientific American. pp. 44–49.
RIDLEY M. 1997. The origins of virtue. Human instincts and the evolution of cooperation. Viking Penguin, New York. 295 pp.
ROBERTS L. 1993. Wetlands trading is a loser's game, say ecologists. Science 260: 1890–1892.
ROLSTON H. 1986. Philosophy gone wild.
ROY B.A. 1994. The use and abuse of pollinators by fungi. TREE 9: 335–339.
SCHWARTAU W. 1994. Information warfare. Chaos on

the electronic superhighway. Thunder's Mount Press, New York. 432 pp.

SELINCOURT A. DE. 1954. Herodotus. the histories. Penguin Books, New York. 653 pp.

SHEPARD P. 1967. Man in the landscape. A historic view of the esthetics of nature. Knopf/Random House, New York. 290 pp.

——— 1973. The tender carnivore and the sacred game. Schribner, New York. 301 pp.

——— 1982. Nature and madness. Sierra Club Books, San Francisco.

SPENCER J.E. 1969. Cultural geography. An evolutionary introduction to our humanized earth. Wiley, New York.

SPROUT M.T. 1941. Mahan: evangelist of sea power. Pp. 415–445 *in* Makers of modern strategy. Military thought from Machiavelli to Hitler. Atheneum/Princeton University Press. New York..

STEARN W.T. 1975. The contribution of Linnaeus to orchidology. Botanical Museum Leaflets. Harvard University 24: 65–84.

STERN P.C. 1993. A second environmental science: human-environment interactions. Science 260: 1897–1899.

STEWART I. 1995. Nature's numbers. The unreal reality of mathematical imagination. Basic Books, New York. 164 pp.

TERRA R.P. June 1991. Islands in the sky: human exploration and settlement of the Oort Cloud. Analog 111: 68–85.

THOMAS W.L., JR., ed. 1956. Man's role in changing the face of the earth. University of Chicago Press, Chicago, Illinois. 1193 pp.

THORNTON I. 1996. Krakatau. The destruction and reassembly of an island ecosystem. Harvard University Press, Cambridge, Massachusetts.

TILMAN D. 1994. Competition and biodiversity in spatially structured habitats. Ecology 75: 2–16.

TILMAN D., R.M. MAY, C.L. LEHMAN AND M.A. NOWAK. 1994. Habitat destruction and the extinction debt. Nature 371: 65–66.

TOFFLER A. AND H. TOFFLER. 1993. War and anti-war. Survival at the dawn of the twenty-first century. Little, Brown, and Co., Boston. 302 pp.

TRAVIS J. 1996. Undesirable sex partners. Bacteria manipulate reproduction of insects and other species. Science News 150: 318–319.

VON BAEYER H.C. 1993. The Fermi solution. Essays on science. Random House, New York. 172 pp.

WADE M.J. AND D.E. MCCAULEY. 1988. Extinction and recolonization: their effects on the genetic differentiation of local populations. Evolution 42: 995–1005.

WILL G.F. 17 April 1997. China's subversion must be the goal. St. Petersburg Times.

WORSTER D. 1977. Nature's economy. The roots of ecology. Sierra Club Books. San Francisco, California. 404 pp.